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THE VIRGINIA JOURNAL OF SCIENCE

VOL. 4, NEW SERIES JULY, 1953 NO. 3

Recent Experiments on the Ferromagnetic Deflection of Mu-Mesons and Electrons[1]

STEPHAN BERKO AND FRANK L. HEREFORD

Department of Physics, University of Virginia

The magnitude of the effective magnetic field acting upon charged elementary particles traversing a ferromagnetic medium was first considered in connection with unsuccessful attempts to deflect cosmic rays in magnetized iron (Rossi, 1931; Mott-Smith, 1931). The problem can be formulated as follows: Given a beam of energetic, charged particles traversing magnetized iron, what is the effective field acting on the particles due to their interaction with the ferromagnetic spin-aligned electrons? This problem leads, as we shall see in the discussion of the theory to the following statement: Any experiment designed to determine the effective magnetic field acting on elementary particles inside a magnetized iron sheet can be thought of as a sensitive detecting device of possible short-range forces between the beam particle and the spin-aligned electrons.

Danforth and Swann (1936) succeeded in first detecting a more or less qualitative magnetic scattering of cosmic rays, and found the effective field to be smaller than the macroscopically defined flux density B. Their approximate computations, however, lack relevant data on the nature of energetic cosmic rays (mesons), and they assume that high energy electrons are responsible for the main cosmic ray flux. Since 1944 several experiments (Bernardini, *et al*, 1945; Rasetti, 1944) led to the result that for Mu-mesons the effective field is of the order of B. All these experiments were performed by studying the counting rate change in a GM telescope, having a block of magnetized iron between its counters. In all their interpretations, multiple scattering in iron played an appreciable role for which theoretical corrections had to be made. The only existing experiment on electrons deflected in magnetized iron was that of L. Alvarez (1934) who used 2.5 Mev electrons and photographic plates for detection. His results show, at best, the effective field to be much smaller than the classical B. In the light of the more recent theory, however, these results seem doubtful, mainly due to the way multiple scattering effects were corrected (Private communication from Professor Alvarez).

[1] Sponsored by the Office of Ordnance Research, U. S. Army.

Editor's Note: For a detailed paper, based on part of the research reported here, presented at the Annual Meeting of the Academy, May 1953, Messrs. Berko and Hereford received the *J. Shelton Horsley Award*. This award is made annually in recognition of the "most highly meritorious paper" presented at the Annual Meeting.

The question was first discussed from the theoretical point of view by von Weizsaecker (1933) on the grounds of the (then) new Dirac quantum theory of the electron. W. F. G. Swann (1936) raised some important objections against the supposition that the effective field has to be necessarily equal to B. These objections were, however, grounded on purely classical considerations.

The most complete theoretical investigation of the problem was carried through by Wannier (1947), using quantum-mechanical computations. He essentially substantiated some of the objections raised by Swann and pointed out the strong influence of possible short-range forces between beam particles and spin-aligned electrons on the final experimentally observed effective magnetic field.

In the following paragraph we shall briefly sum up the essential features of this theory.

THEORETICAL CONSIDERATIONS

Before discussing the theory of the problem to be investigated we will define what we mean by the effective magnetic field acting on a charged particle inside the ferromagnet. The definition is, by necessity, an operational one, relating to a certain experimental process. Given a charged particle with charge e and velocity v traversing an iron foil of thickness x. The particle undergoes a deflection away from its original direction due to the magnetization of the iron foil. This final deflection can be attributed to an *average* Lorentz force acting on the particle along its path through the iron, due to an "average magnetic field" b_{eff} connected by the formula

$$\overline{F}_{av} = C(\overline{v} \times \overline{b}_{eff}) \qquad (1)$$

where C takes care of the respective units.

Next to this definition of the effective field we have that of the classical macroscopic electrodynamics, leading to the flux density B. For our purpose the best operational definition of B is through the usual experimental process of measuring the flux density prevailing inside the ferromagnet: A pickup coil is wound around the iron and connected to a ballistic galvanometer. One measures the total charge passing through it due to a reversal of magnetized current. This leads through the known formulas and the Faraday Law to the quantity 2 B. The difference in the definitions of b_{eff} and B is obvious. The coil used in the experiment to measure B automatically averages over the contributions of all elementary dipoles of the magnet leading to a true average flux per unit area. Since the elementary dipoles in the magnet are of microscopic nature (electron-spins) the particle sees along its path, passing through the ferromagnet. large variations in the magnetization (even negative directions of magnetization within small volumes surrounding the spin-aligned electron). The deflection of the particles will have to be analyzed by computing essentially the average *along* the path of the particle inside the ferromagnet.

The question then is reduced to the following: What are the conditions that lead to $b_{eff} = B$, and what effects would be able to change this result, should the conditions be not satisfied? This question can be answered only after a certain ferromagnetic model is accepted. It is known that ferromagnetism is due to the spin-alignment of 2 of the 26 iron electrons (the 3 d electrons). The "elementary" dipoles which contribute to the magnetization of the specimen are therefore the magnetic moments of these spin-aligned electrons. In order to investigate the nature of b_{eff} for this model, the question arose as to the "true nature" of the magnetic dipole of a Dirac electron. Von Weizsaecker (1933) showed that the Dirac electron behaves from the point of view of its magnetic moment like an elementary current loop of dimensions of the order of h/mc – the Compton wave length.

W. F. G. Swann (1936) derived classically the effective field one would get if one would assume rigid "true dipole moments" as the elementary magnet instead of circulating currents. His final result is, that b_{eff} would be at best equal to $\frac{B + H}{2}$, therefore approximately equal to B/2. Should, however, the circulating dipoles be of current nature, and *should the beam particles be able to penetrate these currents,* (amounting to electron-beam particle interpenetrations) the effective field would be equal to B. The change from $\frac{B + H}{2}$ to B is due therefore, according to Swann, to such interpenetrations.

Wannier's (1947) computations using the quantum-mechanical point of view, follows essentially Swann's steps. He also found that close range interactions between the beam particle and the spin-aligned electrons enter decisively in the averaging process leading to $b_{eff} = B$. Only if each point along the path of the beam particle is given equal statistical weight in this average, allowing for several interpenetrations, will b_{eff} equal B. Should, however, forces exist capable of hindering or favoring such head-on collisions, b_{eff} could be smaller or *larger* than B, according to the repulsive or attractive nature of such possible forces. Wannier performed his computations by introducing a "coincidence probability"

$$p(r) = \frac{\text{chance of finding the electron at r if beam particle is also at r}}{\text{chance of finding the electron at r if beam particle is far away.}} \qquad (2)$$

Letting h be the fictitious average field produced if all electronic dipoles were of "rigid" nature, the introduction of $p(r)$ leads to the following general theorem concerning b_{eff}:

$$b_{eff} - h = 4\pi \int_V p(r)\, \rho\,(r)\, M_a(r)\, dv \qquad (3)$$

where $\rho\,(r) = \overline{X}(r)\, X\,(r)$

$X(r)$ being the psi function, (essentially taken to be a plane wave) of the incident beam particle, and $M_a(r)$ the so-called atomic magnetization at r (see Wannier, 1947).

Using this general theorem concerning b_{eff} Wannier computed the effect due to Coulomb forces. The final result can be expressed as

$$b_{eff} = H + 2\pi M(p + 1) \qquad (4)$$

$$\text{where } p = \frac{4\pi^2 Ze^2}{hv} \Big/ \left(1 - e^{\frac{-4\pi^2 Ze^2}{hv}}\right)$$

v being the velocity of the beam particle.

Due to the nature of the Coulomb forces one gets a deviation from $b_{eff} = B$(or $p = 1$) only for beam velocities of non-relativistic order. At these velocities ($v < 5.10^9$ cm/sec), however, nuclear multiple scattering effects are so large as to make an experimental verification of equation 4 practically impossible.

Should, however, other short-range forces exist between the beam particle and spin-aligned electron, forces having their maximum effect within regions of the order of a Compton wave length, a measurement of b_{eff} would exhibit them through a deviation of b_{eff} from B. In view of the lack of clear cut experimental data on the problem, we have undertaken a thorough investigation employing for the incident particles both high energy Mu-mesons and electrons in independent experiments. The details of this work have been described elsewhere (Berko, 1952, 1953; and Berko and Hereford, (in press). In the following paragraphs emphasis will be placed on the results obtained and their bearing upon the problem at hand.

MU-MESON EXPERIMENT

The meson experiment utilized as a source of incident particles the vertically incident mu-meson component of cosmic radiation at Charlottesville (approximately sea level). Mu-mesons constitute approximately 80% of the total ionizing radiation, and their momentum distribution is well known from previous work. In the present experiment a vertical pencil of mesons was selected by a Geiger counter "telescope" consisting of counters A and B in Fig. I and allowed to fall upon a 15 cm. diameter soft iron core which was part of a closed magnetic circuit. Coincident discharges of counters A and B were recorded in coincidence with 12 similar Geiger counters placed 87.5 cm. below the iron core as shown.

The coincidence rate in each of the 12 channels was recorded with the iron core demagnetized and magnetized to saturation. In order to deter-

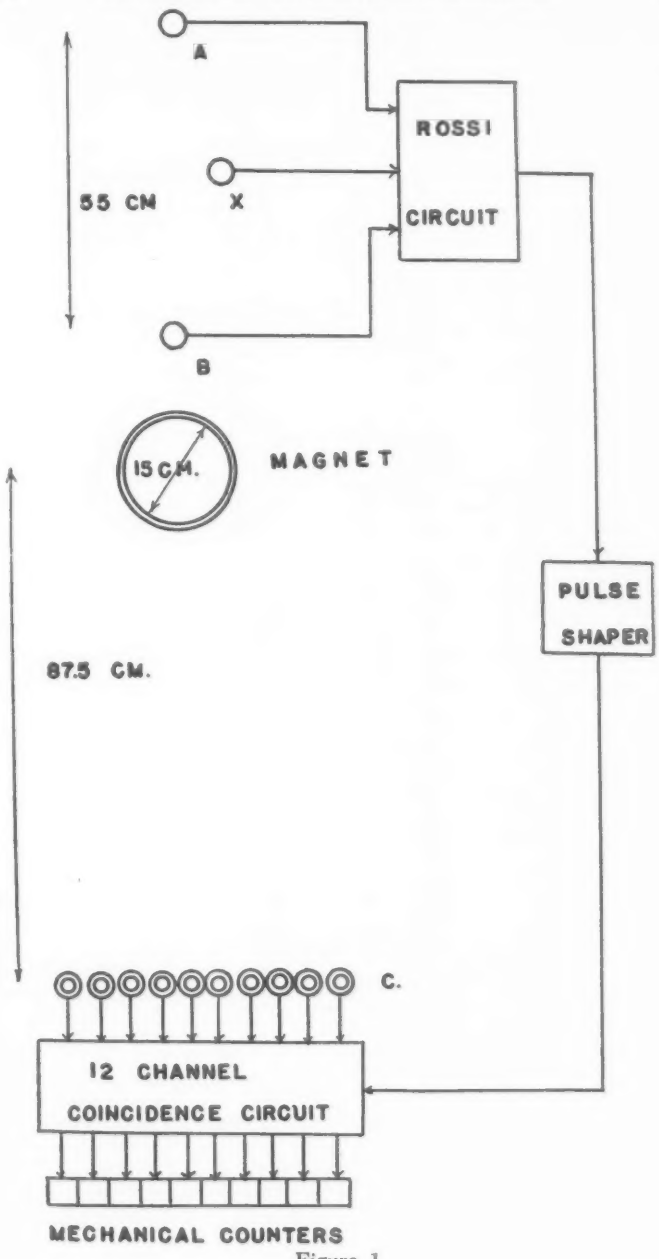
A
ROSSI
CIRCUIT
55 CM
X
B
15 CM.
MAGNET
PULSE
SHAPER
87.5 CM.
C.
12 CHANNEL
COINCIDENCE CIRCUIT
MECHANICAL COUNTERS

Figure 1

mine the influence of cosmic ray showers the out-of-line counter X was also included in a subsidiary experiment. The data are shown in Fig. 2 where the coincidence counting rate is plotted against the counter position. The significance of these curves is as follows. The "no field" curve simply represents the angular distribution of the emergent mesons due to multiple Coulomb scattering in the iron. The "field on" curve is the distribution into which the first curve diffuses due to the ferromagnetic deflection with the iron core saturated. In this experiment the results are not clear cut, because a continuous distribution of meson momenta and mesons of both positive and negative charge are present. The well known positive excess of the sea level meson distribution is shown by the greater extent to which deflections are to the left in Fig. 2. The principal advantage of this method over previous techniques is that the multi-

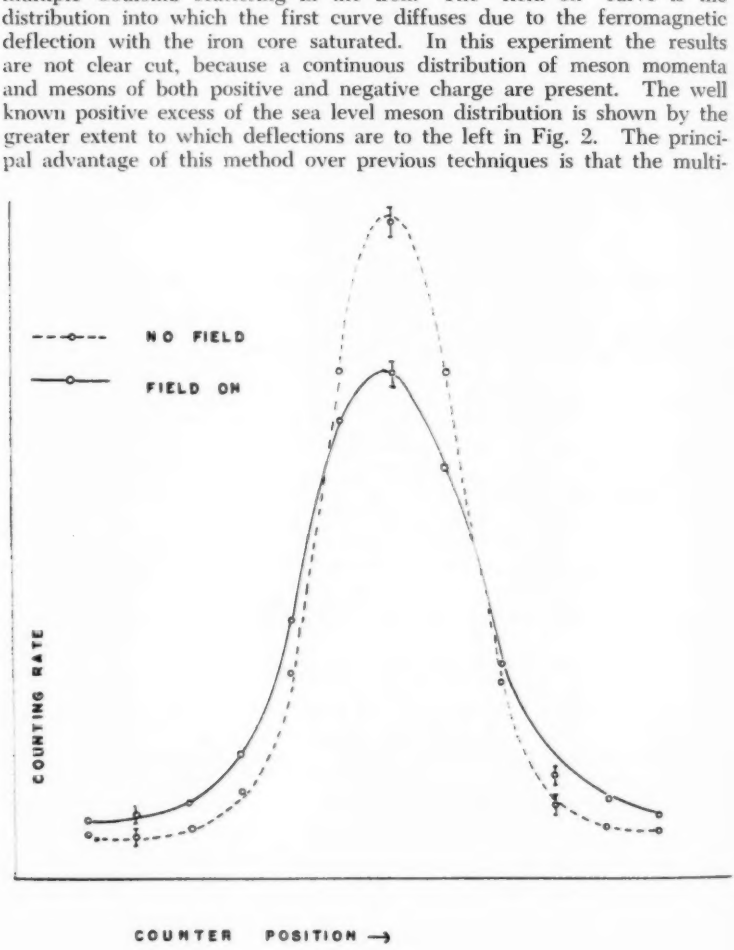

Figure 2

ple scattering effects are actually observed, whereas these effects were corrected for by means of calculations in previous expriments. Nevertheless, the analysis of the curves in Fig. 2 remains a somewhat tedious process. It has been performed by one of us (Berko, 1953); the result only will be stated here. The analysis involves the calculation of the contribution to each channel coincidence counting rate due to deflection of a meson incident with a given momentum which would be multiply-scattered at a given angle in the absence of a magnetic field. One must then integrate this result over the momentum distribution and the multiple-scattering angular distribution. Clearly this computation necessitates the assumption of a value for b_{eff}. It has been found that the assumption $b_{eff} = B$ (saturation value for soft iron) yields excellent agreement with the "field on" curve of Fig. 2. Hence this result indicates that for Mu-mesons the effective magnetic field is equal to the macroscopic flux density B to within the experimental errors (about 5%).

ELECTRON EXPERIMENT

In the case of an incident beam of electrons, one can happily avoid the complications inherent in the meson experiment due to different charges and the inhomogeneity of the beam momentum. To this end we have

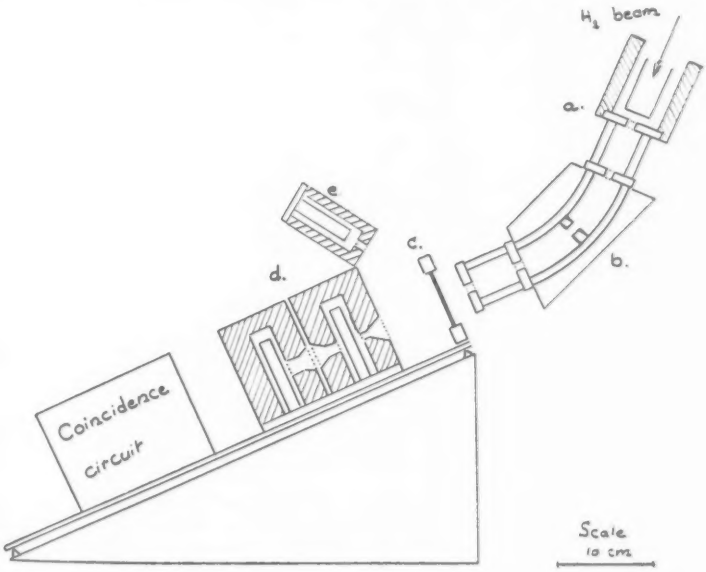

Figure 3

employed the electrons from the beta disintegration of B^{12}. This short lived isotope (.02 sec.) was continuously produced in the course of the measurements by the bombardment of B^{11} by deuterons (B^{11} (d,p) B^{12}). The B^{12} beta-ray spectrum has a maximum energy of 13.4 Mev and thus furnishes electrons of sufficiently high energy to make possible observation of the ferromagnetic deflection superposed on the (larger) multiple scattering deflection. Wannier's (1947) calculations indicate the necessity of higher energies than were used by Alvarez (1934).

The apparatus is shown schematically in Fig. 3. A target of elemental B^{11} was bombarded by 25 microamperes of 1 Mev deuterons from a Van de Graaff machine. The B^{12} beta rays were magnetically analysed to provide a monoenergetic beam of 8.8 Mev electrons. This beam impinged upon a 0.06 cm. sheet of Westinghouse Hyperco (saturating at about 20,000 Gauss) which was part of a closed magnetic circuit at (c). The scattered beam emerging from this sheet was observed by two thin

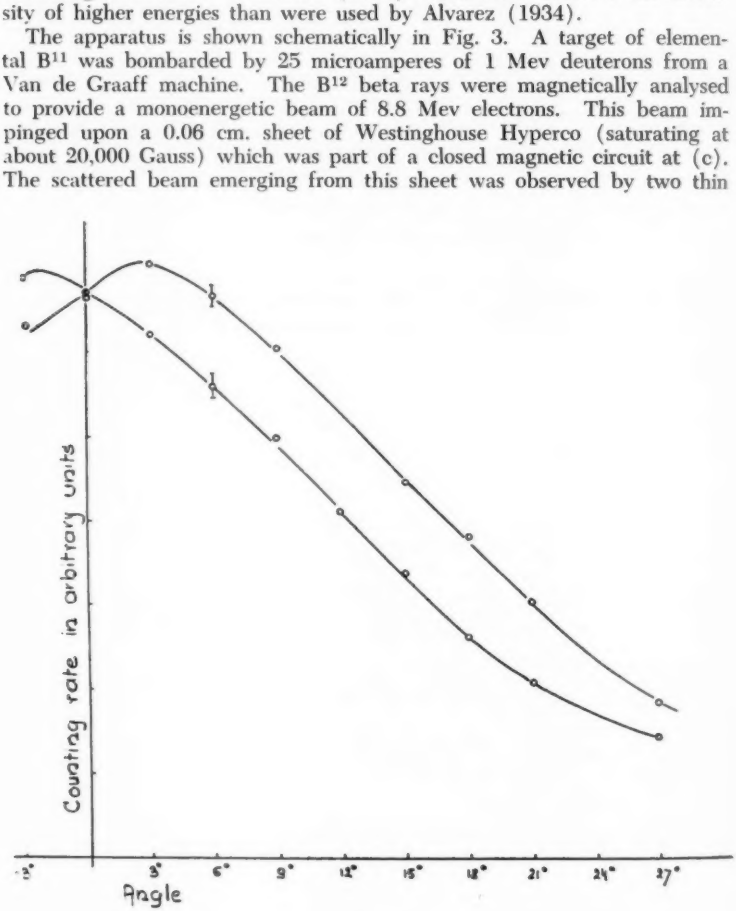

Figure 4

wall (25 mg/cm²) Geiger counters enclosed in lead shields as shown. Coincidence counting rates were normalized with respect to a monitor counter at (e). The two coincidence counters were on a mobile mounting and could be rotated in a plane normal to the diagram about an axis through the Hyperco sheet. Thus, the multiple scattering angular distribution of the emerging electrons was observed with the magnetizing field both up and down. With this arrangement one expects a shifting of the entire scattering distribution due to the ferromagnetic deflection of the electrons. Fig. 4 shows one-half of the multiple scattering curves taken with the field up and down. Each curve is seen to be shifted (one to the right, one to the left). The magnitude of the angular shift is obviously twice the ferromagnetic deflection due to the field in one direction.

The analysis of these data is considerably more straightforward than that of the meson data. Using the known momentum of the incident electrons and the rate of loss of momentum in iron one can compute the value of b_{eff} from the observed angular deflection (Berko and Hereford, in press). By means of a pick-up coil and a ballistic galvanometer the value of the flux density B may also be measured. The results obtained are as follows:

$$b_{eff} = 18{,}400 \pm 400 \text{ Gauss}$$

$$B = 18{,}800 \pm 200 \text{ Gauss}$$

The agreement is considered to be entirely satisfactory in view of the various experimental errors.

CONCLUSIONS

We thus conclude in accordance with the theoretical discussion that no "short-range" forces exist between meson-electron and electron-electron pairs of sufficient magnitude to appreciably alter the Coulomb forces within distances of a Compton wave length.

An extremely interesting possibility is that of performing an experiment similar to those described herein with high energy positrons in an effort to detect possible short range forces between positron-electron pairs. Such forces are known to exist and are due to the virtual annihilation of a positron-electron pair followed by reabsorption of the photon pair. This interaction yields an observable shift in the energy levels of positronium (Deutsch and Dulit, 1951), but no calculations have been performed concerning their possible influence on ferromagnetic deflection.

ACKNOWLEDGMENTS

The authors are indebted to the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, especially to Dr. Norman Heydenburg, for the use of their Van de Graaff machine. The financial support of the Office of Ordnance Research, U. S. Army is also much appreciated.

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Observations on the Life History of *Hesperocorixa interrupta* (Say) (Hemiptera : Corixidae) [1]

MARVIN L. BOBB

Virginia Agricultural Experimental Station, Charlottesville

Hesperocorixa interrupta (Say) is one of the larger members of the family Corixidae. Periodic collections made of *H. interrupta* from a pond known as the "Old Reservoir" near the University of Virginia during 1947 and notes taken on the species from 1946 to 1950 seem worthy of publication since no life history studies have been recorded for any of the species of this genus.

The "Old Reservoir" is a small, spring-fed pond with an abundance of submerged and emergent vegetation, and varies in depth from a few inches at the shoreline to about two feet. The bottom is covered with several inches of black mud and decaying leaves, and during the summer months supports a luxuriant growth of *Elodea*.

Distribution. — *Hesperocorixa interrupta* is widely distributed and has been recorded from Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Ohio, Indiana, Michigan, Wisconsin, Illinois, Arkansas, Nebraska, Missouri, and Quebec and Ontario, Canada.

In Virginia the species has previously been recorded by Hungerford (1948) from Church Bridge, Great Falls (5-16-20), Dogue Creek (7-6-?), Nelson County (7-27-28), and "Virginia".

The writer has collected *Hesperocorixa interrupta* from the following localities in Virginia: *Albemarle Co.* — three ponds near the University of Virginia; *Alleghany Co.* — Griffith (by R. L. Hoffman); *Dinwiddie Co.* — 14.7 miles south of Petersburg on U. S. Hwy. 1; *Henrico Co.* — 8.0 miles east of Byrd Airport at Richmond on U. S. Hwy. 60; *Isle of Wight Co.* — 2.8 miles east of Franklin on U. S. Hwy. 58; *King William Co.* — 10.2 miles southwest of Millers Tavern on U. S. Hwy. 360; *Middlesex Co.* — 5.3 miles north of Saluda on U. S. Hwy. 17; *Surry Co.* — 11.7 miles north of Bacons Castle on St. Hwy. 10.

Habitat and Associations. — This species inhabits ponds, streams, and swamps where individuals are found swimming, or resting on vegetation near the bottom.

Hesperocorixa interrupta has been collected in association with the following members of the family Corixidae: *Hesperocorixa nitida, Palmocorixa buenoi, P. gillettei, P. nana, Trichocorixa calva, T. macroceps, Sigara*

[1] Contribution from the Samuel Miller Biological Laboratories, University of Virginia.

signata, S. *modesta*, and S. *alternata*. The greatest number of associations were with S. *modesta*, S. *signata*, and *H. nitida*.

Life History. — The seasonal data given in table 1 give a fairly good picture of the life cycle. After mating in late summer the males die, and considerable numbers have been seen floating on the surface of the "Old Reservoir" pond in October and November. The adult females, and a few males, pass the winter on the bottom of the pond, but remain more or less active. In 1947 the first nymphs were found on May 15, but hatching had begun earlier as both first and second instar nymphs were found on that date. Probably the majority of the eggs are deposited during April, since dissection of females in early to mid-April contained many fully developed eggs, while in late April some of the females contained no eggs and their ovaries apparently were spent. The overwintering adults began dying in early May and by the latter part of that month very few were alive. During three years of observations the writer has seen but one overwintering adult later than June 1, this one being collected on June 11. Nymphs were first observed to transform into the adult stage between July 4 and July 11. Males and females occur in about equal numbers in July but some males begin to die after mid-August. There are five nymphal stages which require about two months for their total development. There is but one generation per year in Virginia.

Egg: — White when first deposited, darkening to yellow. Ovoid in shape with apex to the side of the principal longitudinal axis. Diameter 0.58 mm., length 0.68 mm. (Fig. 1).

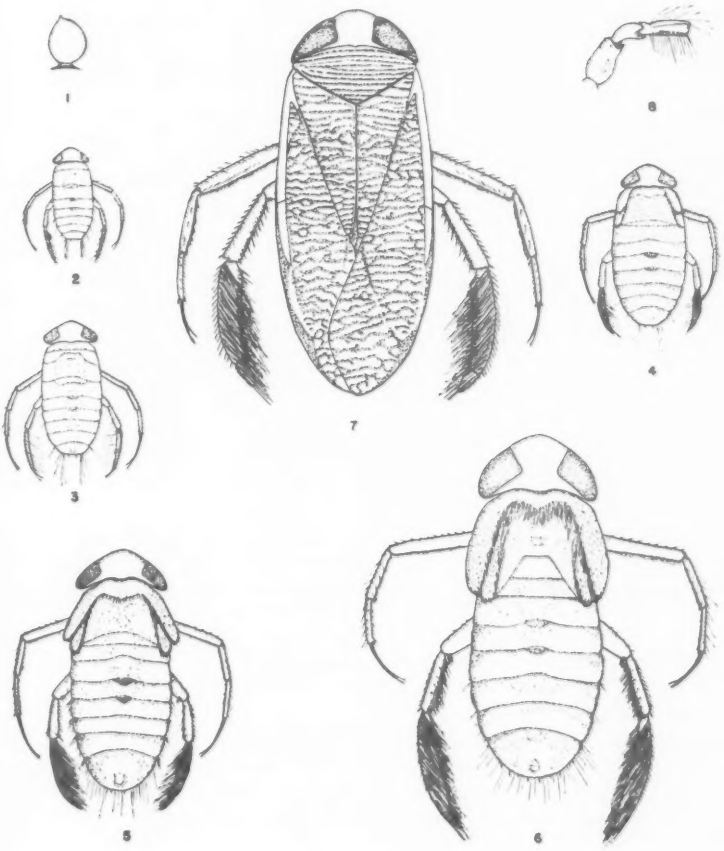
First instar. — General color a pale yellow, almost transparent, with slightly darker areas on thorax; eyes dark red. Body extremely flat with a group of long hairs at caudolateral angles of last segment. Antennae

TABLE 1.—Seasonal data on field collected individuals of *Hesperocorixa interrupta* (Say) from the "Old Reservoir" at the University of Virginia.[2]

Stage	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Adult male	1	2		1			34	10	12	7		1
Adult female	18	25	31	41	7	1	36	22	23	42	19	16
First instar					1	1						
Second instar					25	3						
Third instar					13	7	2					
Fourth instar					1	37	3					
Fifth instar						46	30	2				

[2] It is possible that a small number of the early instar nymphs recorded here are those of *H. nitida* since no characters were known to separate the small nymphs of the two species.

two-segmented. Tarsi of hind legs not conspicuously flattened and with relatively few hairs; two short terminal claws. Middle legs with tibiae and tarsi subequal in length, the latter terminating in two long claws, subequal to tibia and tarsus united. Tarsi one-segmented. No evidence of wing pads. Length 2.12 mm. (Fig. 2).



Hesperocorixa interrupta (Say)

Fig. 1, Egg. Figs. 2-6, First through fifth instars. Fig. 7, Adult male. Fig. 8, Pala of male.

Second instar. – Color and structural characters similar to those of first instar. Abdomen with two reddish-brown dorsomedian spots. Tibiae of hind legs with a row of several long hairs, and tarsi with long hairs more numerous than in preceding instar. Faintest indication of developing wing pads. Length 2.97 mm. (Fig. 3).

Third instar. – General color remains a pale yellow but dorsally with brown bands on cephalic half of each abdominal segment, and thorax uniformly brown. Two reddish-brown dorsomedian spots caudad of third and fourth abdominal segments. Tibiae of middle legs more flattened with numerous swimming hairs; femora stouter and with more numerous hairs. Wing pads extend slightly caudad along lateral margin of thorax, covered with numerous fine, dark hairs, some of which extend across cephalic margin of thorax. Length 4.10 mm. (Fig. 4).

Fourth instar. – General color and markings as in third instar. Hind legs now well adapted for swimming; hind tarsi broad and flat with an abundance of long hairs; claws inconspicuous. Claws on middle legs proportionally longer as compared with length of tarsi. Wing pads extend to caudal margin of metathorax, prothoracic pair covered with very fine pile, both pairs with fine dark hairs along median margins and along cephalic margin of thorax. Length 5.94 mm. (Fig. 5).

Fifth instar. – Color pattern as in preceding instar, but general color slightly darker brown. Antennae two-segmented. Hind tarsi still one-segmented, with short claws. Claws of middle tarsi only about as long as tarsi. Legs stout and well adapted for swimming. Wind pads long, both pair reaching onto the second abdominal segment; thickly clothed with short hairs, and longer, darker hairs along median margin and covering prothorax. Length 8.40 mm. (Fig. 6).

Adult. – Head about one-third the length of pronotum. Pronotum with eight to ten broad dark transverse lines, somewhat irregular caudally. Hemelytra with broad dark bands on clavus in fairly regular series; dark bands of corium narrower and less regular. Lateral lobe of prothorax quadrate, almost straight across apex, broader than long. Pala of male with 28 to 30 pegs in a row along margin. (Fig. 2). Caudal margin of hind femur with about six stout spines on distal portion. Length 9.0 to 11.0 mm. (Fig. 7).

Summary. – Adults frequent lenitic situations throughout the year, but few specimens are to be found during May and June.

The eggs are laid during April and the overwintering adults (the population consisting largely of females at this time) are all dead by the middle of June.

The time required for a newly hatched first instar nymph to reach adulthood is approximately two months. Thus, most of the nymphs have emerged as adults by the end of July.

It seems probable that after the males have copulated the majority of them die, and very few adult males are present after the middle of Octo-

ber. Insofar as the writer is aware, the mass dying of the males in late summer is unique among the aquatic Hemiptera.

There is but one generation per year produced in central Virginia.

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Large Elastic Bending of Cantilevers with Hydrodynamic Loading

PHILLIP EISENBERG AND L. FOLGER WHICKER
David Taylor Model Basin, Washington, D. C.

There are a large number of applications relating to the towing of devices at sea or in a stream which require knowledge of the shape of and forces in the cable or strut used for towing. Much work has been done on the shape and tension of flexible cables (bending neglected) loaded by the forces arising during motion in a fluid (see, e.g., Landweber and Protter, 1944; Pode, 1951), and these can now be computed with considerable accuracy. No results are available, however, for the shape and stresses in elastic members used in such applications when the deflections are so large that linearized beam theory is no longer valid.

In this paper, the intention is to test the accuracy of a solution using the usual linearizing assumptions of elastic beam theory but making no initial approximations in the curvature term of the Bernoulli-Euler equation. Furthermore, it is assumed that the strut is not subject to vibration arising from interaction with its wake, so that the solution is valid only for those cases in which the natural frequencies of the strut are not near the wake frequencies. For the expressed purpose of the paper and for simplification of verifying experiments, it is sufficient to consider only a towed cantilever without the additional loading at the free end representing a towed body.[1]

Derivation of the Elastic Equation.—The hydrodynamic loading is assumed to follow the "sine-squared law", i.e., the unit loading is $R \sin^2 \phi$ where R is the drag per unit length of beam when normal to the direction of motion and ϕ is the angle between the tangent to the beam and the direction of motion. Except for very small angles of inclination ($<10°$) to the stream, this result is well established by experimental evidence and supported by theoretical considerations (see, e.g., Glauert, 1934; Pode, 1950). Here,

$$R = \tfrac{1}{2}\rho U^2 d C_D$$

where

ρ is the mass density of the fluid,
U is the towing speed,
d is a characteristic section dimension of the strut, and
$C_D = C_D(R_d)$ is the drag coefficient (function of Reynolds number

$$R_d = \frac{Ud}{\nu},$$ where ν is the kinematic viscosity of the fluid).

[1] The latter results will be included in a later report.

The tangential component of the hydrodynamic force has been found to be small in comparison with the normal force when the angle of inclination over most of the strut is reasonably large ($\geqslant 10°-15°$), and will be neglected. An assumption that has not been directly verified is implicit in the present work. The sine-squared law has been verified for bars and stranded cables with no curvature; it is assumed here that this law applies locally everywhere on the deformed beam. The fact, however, that this has given accurate results in flexible cable problems is sufficient evidence, though indirect, of its validity.

The coordinate system used and the forces acting on an element of the strut of length ds are illustrated in Figures 1 and 2. The origin of coordinates is taken at the free end of the cantilever, $s = 0$, $\theta = \theta_0$. T, S, and M denote the axial force, shear force, and moment, resp. and W is the weight per unit length. Equilibrium requires, for the horizontal forces,

$$d(T \cos\theta) - d(S \sin\theta) = -(R \cos^2\theta \sin\theta + W)\,ds$$

which, upon integration and evaluation of the integration constant at the origin, yields,

$$T \cos\theta - S \sin\theta = -R\int_0^s \cos^2\theta \sin\theta \, ds + Ws + T_0 \cos\theta_0 - S_0 \sin\theta_0 \quad [1]$$

For the vertical forces,

$$d(T \sin\theta) + d(S \cos\theta) = R \cos^2\theta \, ds$$

and, integrating,

$$T \sin\theta + S \cos\theta = R\int_0^s \cos^2\theta \, ds + T_0 \sin\theta_0 + S_0 \cos\theta_0 \quad [2]$$

In summing moments, we assume that the contribution due to the change in axial force along the beam may be neglected in comparison with those of the weight and normal forces. This is, of course, equivalent to the usual assumption of small curvature of linearized beam theory; however, this has been used in similar problems with excellent results (Bickley, 1934).[2]

Thus
$$-S = \frac{dM}{ds} \quad [3]$$

[2] Bickley's results have also been verified experimentally by Mr. J. S. Brock of the David Taylor Model Basin.

Finally, to obtain the equation of the elastic curve, we take the Bernoulli-Euler result [3]

$$\frac{d\theta}{ds} = \frac{M}{EI} \qquad [4]$$

(since we are considering only beams that are long compared with any section dimension).

Eliminating T between [1] and [2] and combining the result with [3] and [4] to eliminate S gives,

$$-\frac{S}{R} = \frac{EI}{R}\,\frac{d^2\theta}{ds^2} = \sin\theta\left\{ -\int_o^s \cos^2\theta \sin\theta\, ds - \frac{Ws}{R} + \frac{To}{R}\cos\theta_o - \frac{So}{R}\sin\theta_o \right\}$$

$$- \cos\theta\left\{ \int_o^s \cos^3\theta\, ds + \frac{To}{R}\sin\theta_o + \frac{So}{R}\cos\theta_o \right\}$$

For the present purpose of testing the methods used in solving this equation, we take $T_o = S_o = M_o = O$. This assumes that there is no additional loading at the free end even when towed as a cantilever. The flow around the free end, however, actually introduces a force T_o which will be largest when the free end is nearly normal to the stream direction, i.e., at low speeds, and will decrease (relative to R) as θ_o increases. As a result, this effect will be small compared with that of the normal forces and will be neglected.

$$\text{Put } \frac{EI}{R} = c^3 \quad , \quad \zeta = \frac{s}{c} \quad , \quad \omega = \frac{W}{R} \quad , \quad \xi = \frac{x}{c} \quad , \quad \eta = \frac{y}{c} \qquad [5]$$

The shape of the strut is then given by

$$\frac{d^2\theta}{d\zeta^2} = \sin\theta\left\{ -\int_o^\zeta \cos^2\theta \sin\theta\, d\zeta - \omega\,\zeta \right\} - \cos\theta \int_o^\zeta \cos^3\theta\, d\zeta \qquad [6]$$

and

[3] It has been shown by Seth (1934) that for large curvature the bending moment formula must be modified to include second order terms of the type, const. $\frac{h^2}{\rho^3}$, where h is the depth of the beam and ρ is the radius of curvature. An examination of the final results indicate that neglecting these terms is justified within the approximations of the present solution and within the elastic range of ordinary steels (i. e., before failure occurs) as indicated from observations during the experiments cited.

$$\xi = \int_0^\zeta \cos\theta \, d\zeta$$

$$\eta = \int_0^\zeta \cos\theta \, d\zeta \qquad [7]$$

Approximate Solution of the Elastic Equation.—An approximate solution of Equation [6] will be found by expansion in a Maclaurin's series [4]:

$$\theta(\zeta) = \theta(o) + \zeta\,\theta'(o) + \frac{\zeta^2}{2!}\theta''(o) + \ldots \qquad [8]$$

with the following remaining boundary conditions:

$$s = 0 \quad : \quad \theta = \theta_o \quad , \quad M = 0$$

The first ten coefficients are:

$$\theta(o) = \theta_o$$

$$\overset{i}{\theta}(o) = 0$$

$$\overset{ii}{\theta}(o) = 0$$

$$\overset{iii}{\theta}(o) = -\omega \sin\theta_o - \cos^2\theta_o$$

$$\overset{iv}{\theta}(o) = 0 \qquad [9]$$

$$\overset{v}{\theta}(o) = 0$$

$$\overset{vi}{\theta}(o) = 4\omega^2 \sin\theta_o \cos\theta_o + 2\omega\cos\theta_o\,(2\cos^2\theta_o - \sin^2\theta_o) - 2\sin\theta_o\cos^2\theta_o$$

$$\overset{vii}{\theta}(o) = 0$$

$$\overset{viii}{\theta}(o) = 0$$

$$\begin{aligned}\overset{ix}{\theta}(o) = {} & 2\omega^3 \sin\theta_o\,(35\sin^2\theta_o - 14\cos^2\theta_o) \\ & - \omega^2\,(28\cos^4\theta_o + 20\sin^4\theta_o - 227\sin^2\theta_o\cos^2\theta_o) \\ & + 65\cos^6\theta_o - 24\sin^2\theta_o\cos^4\theta_o \\ & + 2\omega\sin\theta_o\cos^2\theta_o\,(111\cos^2\theta_o - 22\sin^2\theta_o)\end{aligned}$$

so that, to this degree of approximation

$$\theta = \theta_o + \frac{\zeta^3}{3!}\overset{iii}{\theta}(o) + \frac{\zeta^6}{6!}\overset{vi}{\theta}(o) + \frac{\zeta^9}{9!}\overset{ix}{\theta}(o) \qquad [10]$$

[4] This procedure was also suggested by McLachlan (1950) for the solution of the heavy elastica. Bickley (1934) obtained results for the latter problem by numerical integration.

The shear is found from [3]

$$\sigma = \frac{S}{CR} = \sin\theta \left\{ \int_0^\zeta \cos^2\theta(a)\sin\theta(a)\,da + \omega\zeta \right\} + \cos\theta \int_0^\zeta \cos^3\theta(a)\,da \qquad (11)$$

and the moments from [3]

$$\mu = \frac{cM}{EI} = \left\{ \int_0^\zeta \sin\theta\gamma \left[\int_0^\gamma \cos^2\theta(a)\sin\theta(a)\,da + \omega\zeta \right] d\zeta + \int_0^\zeta \cos\theta\gamma \left[\int_0^\gamma \cos^3\theta(a)\,da \right] d\zeta \right\} \qquad (12)$$

To the degree of approximation used herein, the bending stress, obtained from the bending moment formula and the usual linearizing assumptions, is given by

$$\psi = \frac{S_{bend}}{E} \cdot \frac{s}{h} = \frac{1}{2}\mu\zeta \qquad [13]$$

where S_{bend} is the bending stress and h is the depth of the beam in the plane of bending.

The effect of the last term in equation [10] is very small up to $\zeta \approx 3$ and $\theta_f = 0°$ for all ω. At $\zeta \approx 5$, the last term approaches the same order as the other terms, but this is already beyond the range of ordinary applications. It is not immediately evident, however, that the terms of higher order are negligible or that the series so obtained are convergent. The form of the general term is not known, and convergence cannot be tested analytically for Equation [10]. As a result, experiments were conducted to determine the accuracy of the above results.

Comparison with Experimental Results.—The experiments were conducted with rods of circular section and lengths of 5, 9, and 10 feet with most data obtained with the latter length. Circular rods were chosen primarily because of the availability of drag coefficients C_D; however, since data are available only for non-vibrating cylinders, it was possible to obtain data with rods only 1/8-inch and 1/4-inch in diameter. Larger rods were tested but the natural frequencies were in the range of vortex frequencies and large vibrations occurred so that these data could not be analyzed.

The towing arrangement is shown schematically in Figure 3. The test specimen was fastened to the lower end of a strut of ogival section which

[3] The shears and moments are represented in these integral forms since greater overall accuracy will be obtained than by taking first and second derivatives of an approximating function with only a limited number of terms.

in turn was bolted to the towing girder of the carriage over the Deep Basin of the David Taylor Model Basin. The drag force was measured by the scale arrangement indicated. The fine deviation from equilibrium was indicated on tape on the revolving drum. Speeds were obtained by a chronograph arrangement also recording on the drum. The resolution in speed was 0.01 knot and in drag 0.005 pounds. Because of the tare drag of the ogival strut, however, the accuracy at the low speeds was much less than these values. For the data presented, it was estimated that the error in drag of the test specimen may be as high as $\pm$ 5%.

Since all tests were made with the rods initially vertical, i.e., $\theta_\ell = 0$, the measured drag is just the total shear. Thus, the total drag S is found from [11],

$$\sigma = \frac{S}{cR} = \int_0^\zeta \cos^3 \theta \, d\zeta \qquad [14]$$

The experimental values were reduced using the following constants: $E = 29 \times 10^6$ pounds per square inch (obtained from tensile tests of several specimens), and $C_D = 1.2$. Because of the manner in which the towing tests were conducted, the rods were towed through fluid having a fairly high degree of residual turbulence induced during the previous passage. Thus, over the entire range of test Reynolds numbers, a constant value of $C_D = 1.2$ could be used (Schiller and Linke, 1933).

The theoretical values of σ were obtained by solving graphically for the value of θ_0 vs. ζ corresponding to $\theta = 0$ for each value of ω, and then integrating equation [14] numerically.

The reduced experimental results are compared with the theoretical predictions in Figure 4. Considering the errors inherent in the assumptions made and in the experiments, the agreement is quite satisfactory. The angle θ_0 corresponding to the highest value of ζ was about 63°.

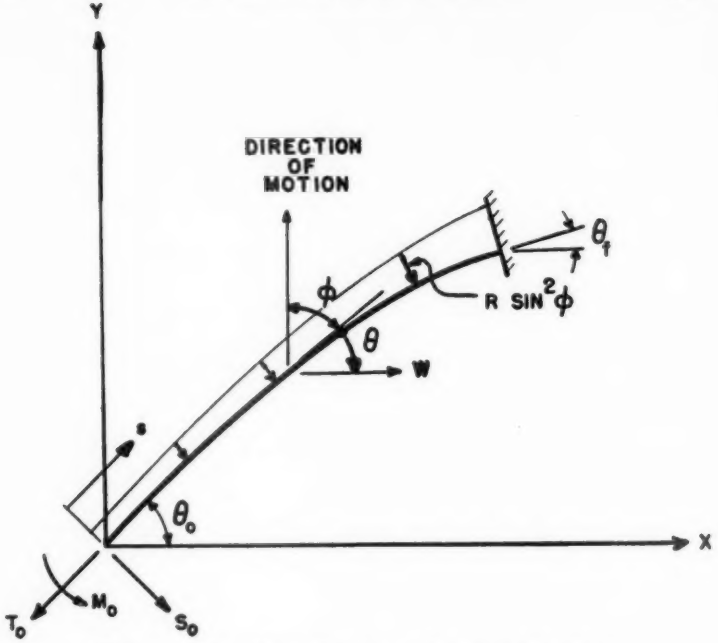

Figure 1.–Coordinate System and Assumed Loading.

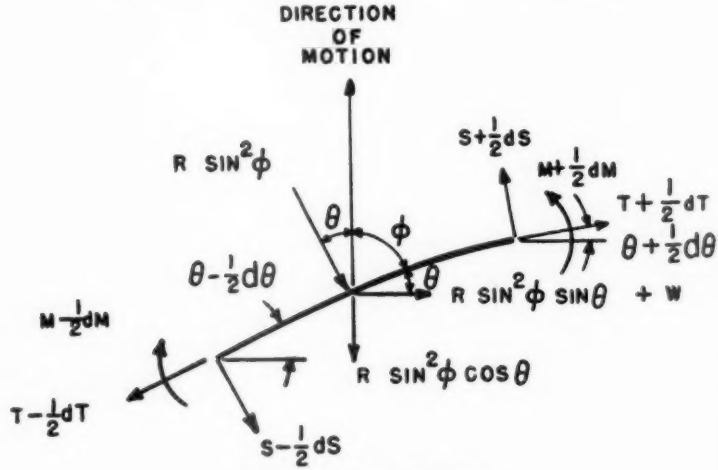

Figure 2.–Force Diagram.

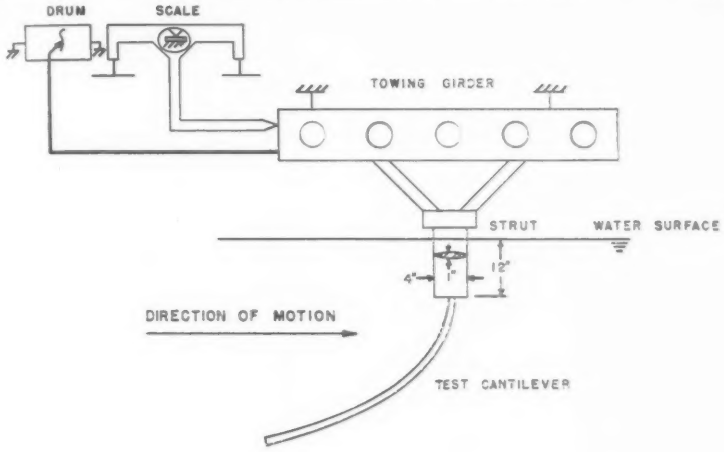

Figure 3.–Diagram of the Experimental Arrangement.

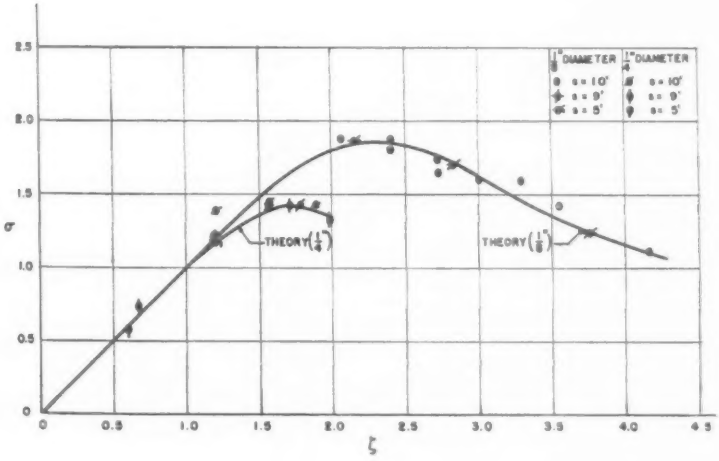

Figure 4.–Comparison between Theoretical and Experimental Results.

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Virginia Bryophytes Collected By Bernard Mikula

PAUL M. PATTERSON

Hollins College, Virginia

During the summers of 1949 to 1950 Mr. Bernard Mikula, engaged in graduate studies at the College of William and Mary, did extensive field work in Virginia. While his interests were primarily in the seed plants, he made approximately 600 collections of bryophytes. As some of the collections were of mixed stands of bryophytes, the total collected is about 750. Some 450 of these are duplicates of 30 common species; however, approximately 130 different species and varieties are in these collections, including 17 species of hepatics.

Mr. Mikula has a good collection of peat mosses, and these are listed in full since our knowledge of their distribution is meager. Only the unusual hepaties and mosses are reported below. His collections were taken from 36 counties in all of the physiographic provinces of the State; however, the majority are from Virginia's southeastern Coastal Plains.[1]

HEPATICS

Frullania Kunzei Lehm. & Lindb.
Norfolk, 9018 in part. Previous reports of this apparently rare southern species have been from Isle of Wight and Princess Anne Counties.

Leucolejeunea conchifolia Evans
Norfolk, 9018, in part; 9020 in part; and 9021-A in part. This is another apparently rare southern species which has been reported previously from Isle of Wight and Nansemond Counties.

PEAT MOSSES

Sphagnum capillaceum (Weiss) Schrank.
9 collections in Greensville, King and Queen, Nansemond, and Southampton Counties.

Sphagnum compactum D. C.
Nansemond, 8502; Westmoreland, 5923.

Sphagnum cuspidatum Ehrh. var. *serrulatum* Schlieph.
Norfolk, 9017 in part. This is a new record for Virginia. The specimen is of an unusual growth form and I am indebted to Dr. H. L. Blomquist for its identification.

Sphagnum cuspidatum Ehrh. var. Torreyi (Sull.) Braith.
Nansemond, 8836, 8347, and 8401.

Sphagnum cyclophyllum Sull. & Lesq.
Norfolk, 9010 in part.

[1] Mr. Mikula's specimens are in the Herbarium of the College of William and Mary; certain of his duplicates are in my herbarium.

Sphagnum henryense Sull.
Nansemond, 8349 and 8407. This is apparently rare in the State. It has been reported previously in Princess Anne and New Kent Counties.

Sphagnum imbricatum Hornsch.
14 collections in Dinwiddie, James City, King and Queen, Nansemond, and Surry Counties.

Sphagnum imbricatum Hornsch. var. *affine* (R. & C.) Warnst.
5 collections in James City, King and Queen, Patrick, and Southampton Counties.

Sphagnum magellanicum Brid.
Greensville, 8704; Nansemond, 8337, and 8341. Previously reported from Caroline, Nansemond, and Princess Anne Counties.

Sphagnum palustre L.
19 collections in Greensville, James City, King and Queen, King William, Louisa, Nansemond, Norfolk, Southampton, Surry, and York.

Sphagnum recurvum Beauv.
13 collections in James City, King and Queen, King William, Nansemond, Norfolk, Richmond, Southampton, and Surry Counties.

Sphagnum strictum Sull.
Nansemond, 8348. The only previous collection is from Dinwiddie County.

Sphagnum subsecundum Nees
17 collections in Charles City, Dinwiddie, James City, Louisa, Nansemond, Norfolk, Shenandoah, Southampton, Westmoreland, and York Counties.

Sphagnum tenerum S. & L.
Nansemond, 8346 and 8414; Surry, 7621. Previously reported from Henrico and Nelson Counties.

MOSSES

Atrichum crispum (James) Sull.
Nansemond, 8504. Previously reported from Caroline, Giles, and Stafford. This species is apparently uncommon.

Polytrichum commune Hedw. var. *perigoniale* (Mx.) B. S. G.
Charles City, 5580; Patrick, 6893. This is a new record for Virginia. My S. E.-336 from New Kent County also turns out to be this variety.

Ditrichum heteromalla (Hedw.) Schimp. var. *orthocarpa* (Hedw.) Paris
This was reported from Southampton County, Patterson (1951), but was not reported as a new record. Mikula's 8511 from Nansemond County is now the second record of this moss.

Tortula fragilis Tayl.
Lunenburg, 8193. It has been previously reported from Augusta and Giles Counties. This is its first report from the Piedmont.

Funaria flavicans Michx.
Mecklenburg, 8179, in part. An uncommon moss, previously recorded from Campbell, Henrico, Prince George, and Roanoke Counties.

Philonotis capillaris Lindb.
James City, 4647; Surry, 5340. The first report of this species in Virginia was that of Flowers (1935). Patterson (1951) in reporting the bryophytes collected by Bayard Long failed to report his No. 2611 in part from Prince George County which is this species. In 1952 Mr. R. L. Hoffman showed me a moss he had collected in the Dan River Gorge in Patrick County which also turned out to be this species.

Chamberlainia cyrtophylla (Kindb.) Grout.
Shenandoah, 5199. This is an infrequently collected moss; previous reports are from Albemarle, Giles, James City, and Roanoke Counties.

Drepanocladus aduncus (Hedw.) Warnst.
Frederick, 5099; Shenandoah, 5266. This is an unusual boreal moss which has been previously collected in Augusta, Botetourt, Giles, Roanoke, Rockbridge, and Smith Counties.

Rhytidium rugosum (Hedw.) Kindb.
Madison, 5442. This is an uncommon moss reported previously from Giles, Greene, and Page Counties. I have also collected it in Botetourt, (R-135, R-136, and R-671); and in Rockbridge, (R-836).

Helodium paludosum (Sull.) Aust.
Charles City, 4963, King and Queen, 5793 & 5937. An uncommon moss previously collected from Caroline and Charles City Counties.

Leskea arenicola Best.
James City, 8223. This one has been reported previously from Prince George, Spottsylvania, and Sussex Counties.

Thuidium Allenii Austin
James City, 4879; New Kent, 8604. An uncommon species previously reported from Norfolk and Princess Anne Counties.

Fontinalis novae-angliae Sull. var. *cymbifolia* (Aust.) Welch
Greensville, 2825, in part. Mr. H. A. Gleason's No. 3077 from Nansemond County is this same variety. My appreciation is hereby expressed to Dr. Winona H. Welch who identified both of these collections. These are the first reports for Virginia since that of Rau & Hervey (1880).

Dichelyma capillaceum B. S. C.
Greensville, 2825, in part. Apparently a very rare moss in Virginia; previously reported from Dinwiddie County.

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Electron Microscopic Analysis of Iron Oxide Pigments

RALPH R. WRIGHT AND WILLIAM C. DECHANT
Virginia Polytechnic Institute

The pigments studied in this investigation are commonly known as hydrated yellow iron oxide pigments. They are manufactured by a corrosion process which was originally covered by the patents of Penniman and Zoph.[1] One of the larger manufacturers of iron oxide pigments undertook a microscopic study of pigments in an effort to check present theories regarding particle size and to correlate particle size and shape with the quality of iron oxide pigment produced. Because of the smallness of the particles[2] involved, it was found impossible to make a satisfactory study of particle size and shape with a light microscope. At the suggestion of the manufacturer an electron microscopic study of samples of hydrated yellow iron oxide pigments made by two pigment manufacturers (hereafter referred to as Companies A and B) was undertaken.

LITERATURE REVIEW

Green in 1921 was the first investigator to describe requirements for completely satisfactory pigment mounts. Employing the technique of rubbing the pigment particles into an exceedingly thin layer with turpentine and mounting them in a soluble medium such as glycerol, he made fairly successful photomicrographs of several types of white lead pigments, zinc oxide pigments, and iron oxide pigments. Photomicrographs of these pigments taken at 1500 diameters are displayed in his paper. From his measurements, he found that the various types of iron oxide pigments analyzed varied from an average diameter of 0.44 to 0.58 micron.

It was later discovered that the technique of pigment mounting developed by Green had two serious disadvantages, i.e., some grinding of the large particles usually occurred and a certain amount of segregation invariably occurred. The second of these disadvantages was overcome by Haslam and Hall in 1930. They gathered all the pigment dispersed in turpentine in the center of the slide. Haslam and Hall not only developed a new technique for mounting paint pigments, but they also used ultraviolet light which enabled them to obtain a higher resolving power than had been used in pigment studies before. By use of a Zeiss ultraviolet microscope and employing a cadmium arc as the source of light (giving a wave length of 2,750 Angstrom units), and by enlargement of their photomicrographs, Haslam and Hall were able to get a total magnification of 3,860 diameters. Although they did not make photomicrographs

[1] Penniman and Zoph, U. S. Patents Nos. 1,327,061 and 1,368,748.
[2] The particle size was found in this investigation to be in the order of 0.5 micron.

of iron oxide pigments, they did make a study of three different types of zinc oxide pigments. They found the coarsest sample to have an average diameter of 0.603 micron and the finest sample to have an average diameter of 0.164 micron. They compared these values of particle size[3] to values for the same sample using visible light as a source of illumination and found appreciable discrepancy in results. This fact would seem to indicate the inadequacy of the ordinary light microscope for determining pigment particle size.

Allen in 1942 described a method of pigment mounting for light photomicroscopy which was an improvement over the methods of Green, and Haslam and Hall. In brief, Allen's method consists of dispersing the dry pigment in high concentration in a suitable optically clear cement. This method makes possible the utilization of the high shearing forces created in the stiff viscous mixture and prevents grinding of the larger particles. The actual mount is then formed by dilution of the dispersion of high concentration already obtained. Employing this method, Allen made successful zinc oxide and iron oxide pigment mounts.

Fuller in 1943, with the aid of an electron microscope, made a crystallographic analysis of the characteristic shape of particles found in zinc oxide produced as a result of burning zinc vapor. He mounted and made successful electron micrographs of these particles at a magnification of 3,500 diameters.

Two methods for preparing a pigment dispersion for electron microscopy were described by O'Brien in 1945. The first method consists basically of wetting the pigment with distilled water and then dispersing it in a solution of cellulose acetate. The second method, which has the advantage of eliminating the possibility of mechanical or chemical damage which is common to the first method, utilizes an electrostatic dispersion apparatus. A complete description of the electrostatic dispersion apparatus used by O'Brien is given in his paper.

Brubaker in 1945 made a comparison of particle size of zinc oxide pigments as determined by light and electron microscopes. By making light and electron micrographs of identical fields, he concluded that the size and shape of particles could be determined much more accurately from electron micrographs.

After making optical and electron micrographs of many types of paint pigments, including zinc and iron oxide pigments, Tilleard and Smith in 1946 reached the following conclusions:

> Because of its extremely high resolving power, the electron microscope offers considerable advantages over the optical microscope in the examination of the sizes and shapes of the ultimate particles of the finer pigments. Such information will not only assist in the study of the nature of these particles and the properties of the finished pigments but also, when obtained at stages in

[3] It is customary in the paint industry to use the expression "particle size" when referring to diameters.

pigment production, should prove of value in studies of the development of pigmentary properties.

To the author's knowledge, Tilleard and Smith are the only investigators of particle size to point out possible pitfalls in electron micrographic analysis of pigments. They raise two important points ot be kept in mind when interpreting electron micrographs of pigment particles.

1. The particles seen in the electron microscope may be only the smaller particles of the pigment. Large particles may in fact be present in the material, but these, particularly if their size is commensurate with the size of the whole field of the microscope, will frequently be neglected.
2. The quantity of material observed, even in traversing a large area of the field of the electron microscope, is very minute, and it is not justifiable to draw quantitative conclusions (*e.g., by counting particles*) except in special circumstances where it is known that the complete range of particle sizes is represented in the electron microscope field.

Tilleard and Smith also compare particle size and shape of a number of pigments commonly used in paints as determined by optical microscopy, electron microscopy, and absorption experiments.

INVESTIGATION

After a careful study of the problems involved, the following objectives were formulated: (1) to develop a technique for making electron micrographs of iron oxide paint pigments, and (2) to determine the gross structure and approximate particle size of the standard types of iron oxide paint pigments made by two different manufacturers of iron oxide pigments.

The first objective proved to be a major problem. In order for the specimen to be suitable for examination with an electron microscope, it is necessary that it not be opaque to an electron beam. The electron beam must pass through the specimen and cast its image on the screen. Nonopacity dictates the necessity of having extremely thin specimens and specimen mountings, and also that the specimen be of such a nature that it will transmit the electrons without being destroyed as a result of electron bombardment. The maximum thickness a specimen can possess is in the order of 0.2 micron.

Objects to be examined by an electron microscope and the technique devised for preparing them can be grouped into four categories: (1) suspensions of small particles; (2) thin section of larger objects; (3) surface films; and (4) surface replicas.The pigments to be studied were in powdered form and thus fall in the first category.

Suspensions of fine particles may be examined by placing them on a very thin membrane or incorporating them directly in the membrane. The

main problem involved is to perfect a technique for obtaining a membrane that will meet the necessary requirements.

There are several techniques and a number of materials which are suitable for fabricating membranes. The most common materials used to form such membranes are collodion, Formvar, and polystyrene in the plastic field, beryllium or aluminum in the light metal field, and silica in the oxide field. Plastic membranes are easier to handle and require less time to make but are more easily destroyed than are some of the others. Oxide films are heat and chemical resistant and more stable than plastic films. The light metal films show excellent stability and can be made extra thin without danger of destruction. It is customary to mount the membranes on screens about 2 mm. in diameter having 200 wires to the inch.

Collodion membranes are quickly and easily made and are satisfactory for mounting many types of specimens. They are prepared from a solution of USP collodion diluted with amyl acetate. The most common method of obtaining this film is to allow a few drops to spread over the surface of distilled water contained in a vessel of not less than ten inches in diameter. The thickness of the film depends upon the number of drops used. The film then requires two to three minutes for drying, after which several 200 mesh screens can be dropped on it. A clean glass slide is next pushed down over the screens and then brought up through the water so that the screens remain on the glass and covered by the collodion film.

Membranes other than collodion can be made in this way, providing the solvent used is not miscible with water. Formvar in ethylene dichloride can thus be used.

Another technique using plastic consists of coating a clean glass plate with a film which is then floated onto a distilled water surface for mounting on grids. The film may be produced on the slide by dipping or by "flowing" it on one side only. Formvar is particularly adaptable for this use. The film can be made to leave the glass and float on the water by starting it with a razor blade or scalpel. If it does not leave readily, breathing on the film may hasten its removal from the glass. The films, once they are water-borne, may be handled like the collodion films. Satisfactory Formvar films that will float freely from glass slides can be made only from fresh solutions.

After the membrane has been produced by one of the previously described methods, the next step is to place the particles to be observed on the surface of the film in such a way that they will adhere to it. It is also necessary that the particles be within one of the openings in the 200 mesh screen in order that they may be viewed on the microscope screen. If the suspension of particles is in distilled water, a drop of the solution may be applied to the film and the water then evaporated. This will allow the particles to adhere to the film and it is probable that some of them will be located in some of the openings in the screen.

In case of non-uniformity of particle distribution, there are several ways in which the problem can be overcome. If the material is in dry powder form, some of the particles can be mixed directly in the plastic and then the plastic handled as before, or the particles can be suspended in distilled water and sprayed on the film-covered screens with an atomizer.

While plastic films are satisfactory for the average electron microscope specimen, in general they possess an undesirable texture when used in conjunction with smaller specimens. For this reason, it is necessary to resort to a smoother film. Films in this category are those made from silica or one of the light metals.

Although many procedures for preparing specimens of pigment for electron microscopy were tried, only the most successful one will be described here.

This procedure is as follows: A film-forming solution was prepared by mixing 35 cc. of amyl acetate (USP) with a 5 cc. solution of collodion (USP). A large glass bowl (about 12 inches in diameter) was cleaned thoroughly and filled to the rim with distilled water. Next, a drop of the collodion solution was applied to the surface of the water and allowed to spread evenly. After two or three minutes, to allow for drying, several of the 200 mesh screens were dropped onto the film to which they adhered. A clean glass plate was then brought down over the screens. The collodion film on the water surface was thus pushed down, folded up around the bottom edge of the slide, and applied evenly on the surface of the glass. The screen disks then were located between the film and the glass. The excess water was drained and the film dried by means of a hot air blast from an electric drier. The glass slide containing the screens and film was then subjected to examination under a Bausch and Lomb vertical light microscope in an effort to ascertain the presence of a uniform collodion film on the screen disk. If a film was found to be present[4] a drop of a dilute solution of the pigment sample in distilled water was placed on the screen and the water evaporated. When this screen was thoroughly dried, it was carefully removed from the glass slide and placed, film side down, in a brass specimen cup. The cup was then mounted on the specimen holder which was in turn placed in the electron microscope specimen chamber for viewing. If a satisfactory specimen was located in one of the screen openings, an electron micrograph was made of the specimen by means of the photographic attachment on the microscope.

The process was repeated many times with samples of pigment, manufactured by Companies A and B. A typical electron micrograph of iron oxide pgiment No. 620 is displayed in Fig. 1a.

From a study of these electron micrographs, it was discovered that gross structures of the same color pigment manufactured by Companies A and B were essentially identical, *i.e.*, rod-like in form. Because of the conglomeration of particles, it was difficult to make accurate measurements of the particles. In order to separate to a greater degree the individual

[4] In many cases, no film was found to be present.

particles so that a more detailed study could be made, various dispersing agents were added to the dilute pigment suspension from which electron micrographs were prepared. After many unsuccessful attempts, electron micrographs in which the individual particles could be accurately measured were obtained. An electron micrograph in which individual particles can be seen is displayed in Fig. 1b. The dimensions of a number of particles of No. 600 pigment manufactured by each company were determined from electron micrographs made at 4274 diameters.

Twenty-five particles of No. 600 pigment manufactured by Company A, which varied in length from 0.374 ot 0.702 micron, had an average length of 0.481 micron and a like number manufactured by Company B, which varied in length from 0.351 to 0.655 micron, had an average length of 0.525 micron.

DISCUSSION

A careful study of electron micrographs, taken at approximately 5,000 diameters,[5] of various samples of yellow iron oxide pigment No. 620 made by two different pigment manufacturers reveals no appreciable difference in individual particle shape. Also, no difference in gross structure was detected in particles of pigment No. 600, manufactured by Companies A and B. All particles observed were rod-like in shape and had a ratio of length to width of approximately five.

The average length of particles of pigment No. 600, manufactured by Company A, based on twenty-five individual particles taken at random, was 0.481 micron. The average particle length of various samples of pigment No. 600, manufactured by Company B, based on a similar number of particles was 0.525 micron. It is felt that the slight difference (0.044 micron) in particle size is not significant.

The most recent and conclusive study of pigments reported in the literature was made by Tilleard and Smith in 1946. Tilleard and Smith investigated several different paint pigments, including the type[6] studied by the investigators. They reported all particles of yellow iron oxide pigment to be rod-like in structure, and further that the dimensions of the majority of the particles measured were 0.5 micron by 0.1 micron.

Although all electron micrographs of yellow iron oxide paint pigments made by the authors were taken at a magnification of slightly less than 5,000 diameters, the results obtained are quite similar to those obtained by Tilleard and Smith with a much more powerful electron microscope.

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[5] All electron micrographs made in this study were made at 4274 diameters. This value of magnification was determined by calibration of the electron microscope preceding the investigation.

[6] Although Tilleard and Smith do not state the manufacturer of the yellow iron oxide pigment investigated, since the work was done jointly at the British National Physical Laboratory and the Paint Research Station, it is reasonable to assume that the pigment was made in England.

CONCLUSIONS

Based on electron microscopic studies of yellow iron oxide pigments manufactured by two different companies, the following conclusions are set forth.

1. Specimens of yellow iron oxide pigments suitable for electron microsopic examination can be made quite satisfactorily by employing a water-borne collodion film.
2. The structure and particle size of yellow iron oxide paint pigments made by two major pigment manufacturers are essentially identical.
3. Particles of yellow iron oxide paint pigment are rod-like in form and approximately 0.5 micron in length.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to the following who aided in one way or another during the progress of the investigation: Professor W. A. Murray, Dr. F. L. Robeson, and Professor M. V. Nevitt, all of the Virginia Polytechnic Institute, and Mr. Roy M. Garrett and Mr. John O. Rider of the American Pigment Corporation.

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Additional Records of the Occurrence of the Freshwater Jellyfish, *Craspedacusta sowerbii*, in Virginia

HORTON H. HOBBS, JR.
University of Virginia

CHARLES H. PAGE
Charlottesville, Virginia

The most recent report of the occurrence of *Craspedacusta sowerbii* in Virginia was that of Tresselt (1950)[1] who recorded its presence in Matoka Lake at Williamsburg, James City County, Virginia. Previous reports include those of Schmitt (1939)[2] and Hamaker and Milne (1937)[3].

Dr. W. E. Brown of Charlottesville kindly presented the senior author with three specimens of this jellyfish which he had collected in Paynes Pond on August 13, 1950. Payne's Pond, which was destroyed by high water during 1952, was formed by an impoundment of Little Mechunk Creek, a tributary of the Rivanna River, in the northwestern part of Fluvanna County. The pond was visited on August 15 to look for additional specimens Between 10:00 and 12:00 A. M. the sky was overcast, and thousands of medusae were seen. While the medusae were more abundant some 50 feet off shore, a few individuals were observed in water less than one foot deep. At this time approximately 200 specimens, ranging from one to 12 mm. in diameter, were collected and preserved. Subsequent visits to the pond later in the Fall and during the following year, however, failed to disclose their presence.

The junior author observed medusae in two localities during 1950 but did not preserve specimens from either of them. It is assumed that they were the same species as the other freshwater medusae recorded from the State.

In Holladay Lake, an impounded tributary of the Appomattox River in the eastern part of Appomattox County, he found many individuals in the lower portion where the water was comparatively deep. On the other hand, in Bear Creek Lake, a lake formed by a dam built on Bear Creek, also a tributary of the Appomattox River in Cumberland County, he found the medusae in the upper, shallow reaches. They were seen during the first week-end in September in the former locality, while in Bear Creek Lake they were present from late July through September.

The three localities in the Piedmont Province represent the westernmost records for this species in Virginia. It is hoped that others who observe jellyfishes in fresh water in the State will kindly inform one of the authors, both of whom are interested in ascertaining the range of this animal.

[1] Ecology, 31 (3): 478.
[2] Amer. Nat., 73 (744) 83-89.
[3] Science, 86 (2238): 494.

Justus Henry Cline (*right*) discussing deer food habits with Editor of Virginia Wildlife in Big Levels Refuge.

JUSTUS HENRY CLINE

The Conservationist-Geologist of Virginia

The next time you are in Stuarts Draft, Virginia, go to the local farmer's supply store and the chances are that you will find Virginia's most famous and beloved conservationist-geologist sitting in an old chair passing the time of day with someone – it may be a 'teen age fisherman or a United States Senator. Justus Henry Cline, "Judd" to his many friends, is one of the Commonwealth's most sincere and active conservationists and geologists. He was born on a farm near Timberville, Virginia, obtained a Bachelor's degree from Bridgewater College, a Master's degree in geology from Northwestern University, taught geology and did research at the University of Virginia under Thomas L. Watson, and participated in exploration for oil in vast areas of the far west as geologist for several of the major oil companies.

His thoughts and ideas have always been far ahead of those of most people. Through his interest in wildlife protection, the Big Levels Wildlife Refuge was established. At the entrance to Sherando Lake Park a bronze plaque mounted on a boulder commemorates "Judd's" work in establishing this area as a haven for wild animals and man. Within full view of his boyhood home at Stuarts Draft, to which he has returned, is the latest monument to his foresight and geological knowledge, a dam impounding a lake which supplies ample water for one of the few rural water supply systems of the United States.

In May 1950 a volume on *The James River Basin – Past, Present and Future*, published by the Virginia Academy of Science, was dedicated to him jointly with Wortley F. Rudd. In May 1953 the members of the Academy again honored him by election as an Honorary Life Member. On June 1, 1953 his Alma Mater, Bridgewater College, recognized its famous alumnus by awarding him the degree of Doctor of Science.

Now when we go to Stuarts Draft we will ask at the feed store, the post office or at his home for Doctor Cline, but he will still prefer "Judd."

MARCELLUS H. STOW
Lexington, Virginia

News and Notes

(EDITOR'S NOTE: *News contributions should be sent to the person whose name appears at the end of the appropriate section.*)

PRESIDENT'S MESSAGE

The Editor of the Virginia Journal of Science has offered me this opportunity to say a few words to the members of the Virginia Academy.

Since the Academy was founded thirty years ago, the role of science in world affairs and its influence on the individual have changed greatly. Because of the increasing importance of science to our military and economic security, it has become more centralized, more secretive, and more mercenary. Consequently science is having less and less intellectual and spiritual appeal to the individual.

It is in the relationship of science to the individual, I believe, that the Virginia Academy may be able to play its most important role in the future. Because it is concerned with a greater appreciation of science by the local communities, because it is interested in the development of the individual scientist, because it embraces all of the natural sciences, because its members will undertake a difficult job which no one else will do, just so long as it needs to be done, such as the monograph on the James River basin, and because of many other similar reasons, I believe that the Virginia Academy renders a unique service in making science an integral part of the life of the community. It does this as no other organization that I know can do. It has appeal to the individual in that it is uncentralized, unsecretive, and unmercenary. It is a labor of love, and that is one reason why it can give to science that intellectual and cultural appeal which only voluntary activities possess.

It may be that such modest local organizations as the Virginia Academy of Science, which brings science down to earth and which relates it to the individual and to the local community, will in time save the day for science and democracy. Let us hope that the Virginia Academy will take full advantage of its opportunities to serve the state and nation in these respects where many mighty organizations cannot prevail.

— ALLAN T. GWATHMEY

MINUTES OF THE COUNCIL MEETING OCTOBER 12, 1952, LEXINGTON, VIRGINIA

The meeting of the Council of the Virginia Academy of Science was held in the library of Mallory Hall, of the Virginia Military Institute, Lexington, Virginia, October 12, 1952. President Lloyd C. Bird presided.

Present were Council members: Walter S. Flory, Jr., Ladley Husted, I. G. Foster, Sidney S. Negus, Marcellus Stow, Paul M. Patterson, Guy S. Horsley, Boyd Harshbarger, President-Elect Allan T. Gwathmey, and Foley F. Smith. Colonel S. M. Heflin and Mr. Truitt, of the Staff of V. M. I. were also present.

President Bird called the meeting to order at 9:45 A.M. The first order of business concerned the Virginia Academy Conference. It was proposed that the reading of the Committee reports be eliminated in order to save time; and be limited to five hundred words for printing in the Proceedings.

Marcellus Stow suggested that the reports be mimeographed in advance and be made available for each member desiring it for information previous to printing in the Proceedings. The reports of the Finance Committee, the Research Committee, and that of the Secretary would be read before the Conference; and copies of the reports should be sent to the Council in advance so that any controversial matters which might arise could be discussed before the meeting. It was properly moved and seconded that the Secretary instruct each person authorized to make a report to submit such Committee report to the Secretary at least a week before the annual Conference Meeting, and that copies of such reports be mimeographed on letter size paper and made available for all members who registered at the meeting.

It was further moved, seconded and passed, that such reports, or summaries of four hundred words or less be sent to the Editor-in-chief of the Virginia Journal of Science for publication; unless a more complete report for publication is required by the Council.

A sum of $2,500 of the general funds was authorized to be invested in recognized securities, the income of which is to be used for general expenses of the Academy.

Marcellus Stow reported on the status of the proposed Dismal Swamp Project for the Long Range Planning Committee. He stated that the lowering of the water table in the swamp and the program of reforestation by the Camp Manufacturing Company would gradually change the swamp from its present natural status, and consequently the proposed study would not have the interest that was contemplated. He suggested that a further study be made of the situation, and a further report made at the Annual Meeting.

President Bird read a letter from Henry Leidheiser of the Virginia Institute of Scientific Research in which he suggested a "New Activities Com-

mittee." It was suggested that the President answer Mr. Leidheiser's letter, and appoint him on the Long Range Planning Committee.

President Bird told the Council about the William Ralston Memorial Award that had been established to encourage good expression in scientific writing. It was suggested that, subject to the approval of the Executive Committee of the Virginia Section, the Award might be handled advantageously through the Academy. After considerable discussion, the suggestion was approved in principle.

It was moved, seconded and passed, that President-Elect Allan T. Gwathmey, be appointed as a delegate to the Academy Conference of the AAAS at the St. Louis meeting, in addition to the Secretary.

After considerable discussion it was moved and passed that the customary Academy dinner, both Junior and Senior, be eliminated.

The Council recommended that the President contact college and university authorities regarding the possibility of increasing the value of scholarships offered to State Science Talent Search winners; and also the possibility of continuing such scholarships for four years.

It was moved, seconded and passed, that the fiscal year of the Academy be changed to correspond with the calendar year. This action is subject to the approval of the Academy at the Annual Meeting. It was suggested that the Secretary and Editor-in-chief work out details and conflicts which might arise due to such change.

Since such action would require change in the Constitution Article II. Section 2, which now reads: "The fiscal year of this organization shall be from April 1 to March 31." This to be changed to read: "The fiscal year of this organization shall be from January 1 to December 31." Publication of this notice in the Journal shall constitute the proper notice.

It was moved, seconded and passed, that the present fee of $10.00 for the Collegiate Chapter be changed to $3.00 per year, for which such Chapters will receive one subscription to the Virginia Journal of Science instead of two.

Dr. Boyd Harshbarger discussed bids offered for publication of the Journal for the coming year, and on his recommendation it was moved. seconded and passed, that the bids of the Pearisburg Virginian, by Malcolm Donald Coe, be accepted for two years. There being no further business the Council adjourned at 12:20 P.M.

Following lunch the President's Advisory Committee convened in the library at 2 P.M. Most of the members of the Local Committee on Arrangements were present and problems relative to the Annual Meeting at V. M. I. were discussed for the benefit of the committee.

Present were: Major Nichols, Colonel Anderson, Messrs. Dobson, Jarman, and Webb, of V. M. I.; Mrs. Zoe Black, Mrs. Vera Remsberg, Messrs. Stow, Brumfield, Jopson, Myster, Flory, Harshbarger, Obenshain, Patterson, Horsley, Weaver, Truitt, Gwathmey, Negus, Carroll, Foster, Smith, and Bird. Also Colonel Heflin, Robert Jeffrey, and Mrs. B. G. Heatwole were present. Mr. Obenshain made a report to the group on the new

set-up of the Speakers and Councilors Bureau. Colonel Carroll, of V. M. I., reported on the activities of Collegiate members.

Mrs. Heatwole made a report on the plans for the program of the Junior Academy meeting and publicity that was being planned.

Colonel Anderson expressed the pleasure of V. M. I. in entertaining the Academy at its Annual Meeting.

The meeting adjourned at 5 P.M. — FOLEY F. SMITH, *Secretary.*

MINUTES OF THE COUNCIL MEETING RICHMOND, APRIL 18, 1953

A meeting of the Council of the Virginia Academy of Science was held at the Commonwealth Club, Richmond, April 18, 1953, at 12 o'clock noon. Present were: President Lloyd C. Bird, who presided; I. G. Foster; Walter Flory; President-Elect Allan Gwathmey; Edward Harlow, Boyd Harshbarger; Guy W. Horsley, Ladley Husted; Sidney Negus, Marcellus Stow, and Foley F. Smith. Mrs. B. G. Heatwole, Chairman of the Junior Academy of Science Committee, was present as a guest.

It was decided to hold the Annual Academy Conference on Thursday afternoon, May 7, at 5 P.M. in Mallory Hall, at the Virginia Military Institute. It was felt that since these conferences would be shorter, due to condensed reports, the meeting could be concluded within an hour.

President Bird asked for some committee reports, and comments were made by Marcellus Stow, for the Long Range Planning Committee, and for the Committee on Secondary Education. Mimeographed reports concerning these committees were distributed among those present.

Walter Flory, Chairman of the Research Committee, requested a statement of policy from the Council concerning various items of equipment which might be purchased through a grant-in-aid made to an individual by his committee. After much discussion it was moved, seconded, and passed, that each case be considered on its merits, and disposition of such equipment be left to the discretion of the committee.

Mrs. Heatwole was congratulated on having been awarded a Ford Travelling Scholarship in the amount of $4,300 which would allow her to take a year's leave of absence to do some creative writing and visit various high schools throughout the country and observe their secondary science teaching program.

Recognition was made of the fact that two scholarships available to teacher sponsors; one each offered by the College of William and Mary and the University of Virginia, to the Biological Station at Mountain Lake, had been increased to $200.00 each, by these institutions.

Dr. Guy Horsley commented on the encouragement received so far in planning to establish an endowment fund, the interest of which would be utilized in carrying on the Junior Academy and Science Talent Search program.

The matter of establishing a scholarship to be awarded by the Academy was referred to the Finance Committee.

President Bird stated that the University of Virginia, Department of Education, was making some plans to study the careers and accomplishments of former State Science Talent Search winners, and to make such a study continuous from year to year.

It was suggested that the incoming administration further consider the problem of Collegiate Chapters of the Academy and suggest that the present committee be discharged at this time.

It was noted that the Committee on Resource-Use Education had arranged a program for one of the first symposia that has ever been held by the Academy including more than one section.

President Bird read a letter from Dr. Baldwin, of William and Mary, proposing the establishment of a chair of Botany. It was moved, seconded and passed, that such a proposal was not feasible at this time and that President Bird write Mr. Baldwin to this effect.

The problem of the State Science Museum was discussed and it was suggested that the Academy study a new approach to secure an adequate building; as it was felt that the State Finance Building would not be available at any time in the near future.

I. G. Foster reported for the Local Committee on Arrangements for the annual May meeting at the Virginia Military Institute, and stated that everything possible had been done to insure a successful meeting.

In order to be able to furnish better service to the individual sections of the Academy, it was suggested that the addressograph plates now used by the Virginia Journal of Science, and located in Blacksburg be brought to Richmond and turned over to a mail service company which could better maintain an up-to-date correct list of members; and could more readily and promptly make requested changes in the file than could be done at present. A bid for this contract from the Expert Letter Writing Company of Richmond, advised that such service of tabbing the plates for automatically addressing envelopes and bill heads, etc., for the various sections, and the Academy as a whole; and proper maintenance of addressograph plates including changes and addressing envelopes for mailing the Journal could be done for forty-five to fifty dollars per year.

The suggestion was favorably received by all present and it was suggested that official action be taken at the May meeting, after further study by the Editor-in-chief of the Journal.

At the suggestion of Boyd Harshbarger it was moved, seconded and passed that Malcolm D. Coe of the Giles County Virginian, publishers of the Virginia Journal of Science, be commended for his personal interest in supervising the publication of the Journal.

The William Ralston Award was established in 1949 to encourage clarity of expression and accuracy in the preparation of scientific papers. Under a plan that has evolved this year, undergraduate students in Chemistry, Physics, Biology, Engineering, Astronomy, Mathematics, Geology, and Agricultural Science, as well as medical students, are eligible. Sections of

the Virginia Academy of Science, embracing these fields, have been asked to cooperate in securing suitable papers. Under this plan, the Awards Committee of the Virginia Section, ACS will continue the administration of the Award. The Chairman of the Virginia Section ACS will make the Award at the annual meeting of the Academy.

It was also moved, seconded, and passed that Edward Dyer, Chairman, of the Science Talent Search Committee and Mrs. B. G. Heatwole be commended for their excellent work in preparing and conducting the program instituted by these committees during the past year.

It was moved, seconded, and passed that Justus H. Cline of Stuarts Draft, be elected an Honorary member of the Academy. A properly embossed certificate will be presented to him at the annual meeting.

It was moved, seconded, and passed that the President appoint a standing committee to study and to select those members of the Academy to be elected to Honorary membership.

President-Elect Gwathmey suggested the possibility of securing grants from the Research Corporation, over and above those made available by the Virginia Academy of Science. He was requested to study this possibility further.

There being no further business the Council adjourned at 3:30 P.M.

— FOLEY F. SMITH, *Secretary*

SECTION NEWS

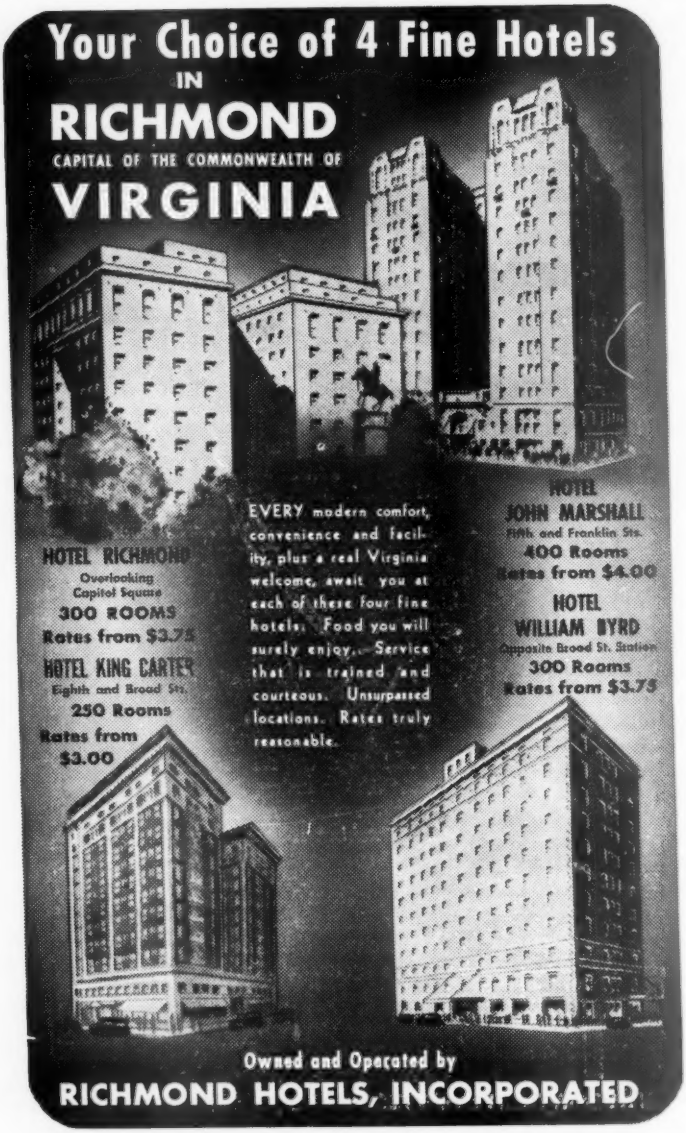
CHEMISTRY SECTION

Lloyd Campbell Bird, President of Phipps and Bird, Inc., of Richmond, Virginia and a member of the Virginia State Senate has been selected by the Awards Committee of the Virginia Section, American Chemical Society, to receive its annual Distinguished Service Award given for outstanding contributions to the professional standing of chemists.

Miss Susie V. Floyd, Science Instructor at Newport News High School, Newport News, Virginia, was also selected by the Virginia Section to receive a Distinguished Service Award for 1953 in recognition of her outstanding contributions to the stimulation of interest in high school science.

Mrs. Thelma Crowley Heatwole, Chemistry and Science Instructor at Wilson Memorial High School, Fishersville, has been awarded a $4,300 fellowship for a year's special study by the National Committee on High School Teacher Fellowships, set up by the Ford Foundation. Of the hundreds of high school teachers over the country who were nominated for this honor, about twenty-five science teachers were selected. Mrs. Heatwole is the first teacher of secondary school science in Virginia to receive this Ford Fellowship. The grant covers travel, study and research in Mrs. Heatwole's special fields, and will also allow her to devote some of her time to writing projects in which she is interested.

Mrs. Heatwole has been honored in many ways as an inspiring teacher of high school chemistry. In 1949 the Virginia Section of the American Chemical Society presented her with its Distinguished Service Award for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outstanding contributions to high school teaching. For a number of years, her students have been winners in the National and State Science Talent Searches and Virginia Junior Academy of Science contests. At the present time she is chairman of the Virginia Academy of Science committee for the encouragement of "junior scientists" in the State. Mrs. Heatwole will begin her special work next fall.

Dr. James K. Shillington, who received his doctorate at Cornell University and who is now teaching at Amherst College, has been appointed to the chemistry staff at Washington and Lee University as an assistant professor.

Bentz B. Howard of Danville, Virginia, who receives his degree in chemistry this year from W. and L., has been awarded a National Research Council Fellowship and will study at Princeton University.

Mr. D. K. Marchand has resigned his position on the chemistry staff at the Virginia Military Institute to accept a position at Washington and Jefferson College, Washington, Pennsylvania.

Dr. Gene Wise and Dr. B. W. Mundy, both of the V. M. I. staff, have accepted summer positions. Dr. Wise will serve as a research assistant in the chemistry department of Northwestern University, and Dr. Mundy has been appointed to the summer school staff at the University of Virginia.

Mr. Charles W. Bondurant has resigned his position on the chemistry staff at Hampden-Sydney College to resume graduate work at the Virginia Polytechnic Institute next fall. Mr. James B. Worsham, Jr.. who receives his doctorate from Duke University this June, will replace Mr. Bondurant on the Hampden-Sydney staff.

Recent additions to the staff of the Virginia Institute For Scientific Research include Felix von Gemmingen and Donald Koenig, both of whom hold master's degrees. Mr. Gemmingen is a graduate of V. M. I. and Rensselear Polytechnic Institute and will be in charge of X-ray work and the electron microscopy section. Mr. Koenig comes from the University of Pittsburgh and will assist in ultracentrifugal studies on protein materials .

Dr. Robert C. Krug, Associate Professor of Chemistry at V. P. I., will join the summer staff of the Virginia Institute For Scientific Research to study the properties of organic single crystals.

— CARL J. LIKES, *Virginia Institute For Scientific Research*

ENGINEERING SECTION

The Aeronautical Engineering Department of V. P. I. has announced the return of Assistant Professor James B. Eades, following two years on active duty with the Navy, and the appointment of Mr. Fred W. Martin as Instructor in Aeronautical Engineering.

A recent publication from the Aeronautical Engineering Department of V. P. I. is "A Method for Location of Detached Shock Waves Ahead of Plane Bodies", by R. W. Truitt, in the Journal of the Aeronautical Sciences, January, 1953.

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The Aeronautical Engineering Department of V. P. I. has secured a research contract with the U. S. Air Force, Air Research and Development Command, to undertake a theoretical investigation in the transonic range over simple wedges.

Mr. Kenneth C. Rathbun has joined the staff of Experiment Incorporated in Richmond as a Research Associate. Mr. Rathbun is a graduate of the University of Virginia, 1942, and recently attended M. I. T. obtaining his Master's degree.

Two recent publications in the Transactions of ASME announced by Experiment Incorporated are "Static Dynamic Load Machine for High Pressure" by E. G. Dorsey, Jr. and E. T. Fleischauer, and Seals to Minimize Leakage at Higher Pressures" by B. A. Niemeier.

Dr. Joshua S. Bowen, Jr., who obtained the Ph.D. degree in Chemical Engineering from Johns Hopkins University, and Mr. John Albert Rolston, who recently obtained the M.S. degree from North Carolina State have joined the staff of the Engineering Experiment Station of the University of Virginia.

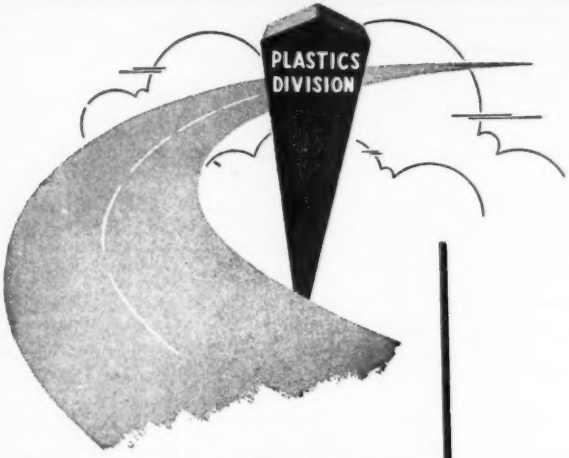
Dr. James Hubert Gary joined the staff of the Department of Chemical Engineering of the University of Virginia in September 1952. He obtained the B.S. degree in Chemical Engineering in June 1942 and the M.S. degree in September 1946 from V. P. I., and the Ph.D. in Chemical Engineering from the University of Florida in June 1951. He was most recently employed as an engineer in charge of a pilot plant development group by the Standard Oil Company of Ohio. He holds the rank of Assistant Professor of Chemical Engineering and is in charge of a research project in the Engineering Experiment Station sponsored by the Engineer Research and Development Laboratories at Fort Belvoir.

Assistant Professor J. W. Eldridge of the University of Virginia Department of Chemical Engineering and Mr. M. G. Selden have published an article entitled "Coating Ingredients from Tall Oil" in the monthly journal of the Technical Association of the Pulp and Paper Industry.

The Second Annual Highway Materials Conference was held March 31 and April 1 and 2 at the Virginia Council of Highway Investigation and Research located at the University of Virginia in Charlottesville. More than twenty members of the Highway Department Testing Division, District Materials Engineers and members of the Research Council Staff met in informal sessions to discuss materials problems and to exchange information.

Mr. Tilton E. Shelburne, Director of Research of the Virginia Council of Highway Investigation and Research was elected First Vice-President of the Virginia Section of the A.S.C.E. on December 5 when the Society met at Richmond's Hotel Jefferson.

Research publications of the Virginia Council of Highway Investigation and Research from the Proceedings of Highway Research Board include "Curing of Soil-Cement Bases", by A. W. Maner, and "Temperature Variation and Moisture Retention of Concrete Curing Methods" by Phillip L.



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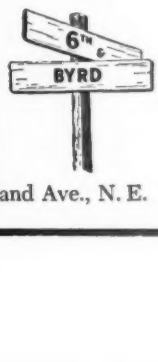

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Melville and R. W. Czaban. Bulletin No. 57 of the Highway Research Board includes a paper entitled "Field Studies of Traffic Paints" by Tilton E. Shelburne, A. L. Straub, and R. L. Sheppe. — N. F. MURPHY

PSYCHOLOGY SECTION

The Virginia Examining Board for Clinical Psychologists met in Richmond on May 23. Mr. Ralph W. Colvin and Mr. Edward V. Malcom were recommended for certification on the basis of examination. Mr. William Morgan was also interviewed and will be recommended for certification by reciprocity, since he already holds the certificate of the American Board of Psychological Examiners.

The College of William and Mary is inaugurating a program of graduate instruction in Psychology, featured by a work-study plan sponsored jointly by the College and the Eastern State Hospital. Two students per year will be accepted for this program calling for half-time work as an intern in abnormal psychology at the Hospital, combined with graduate study in general and experimental psychology at the College. This program will lead to the M.A. degree at the end of two years.

The Washington and Lee chapter of Psi Chi initiated Mr. Frank A. Geldard as a member on May 1. Mr. Geldard addressed the chapter on the topic, "Psychological Problems in the Defense Situation."

Three Virginia psychologists participated in the 45th annual meeting of the Southern Society for Philosophy and Psychology, held at the University of Texas on May 2-4. Mr. Frank A. Geldard gave an address, "Scientific Psychology in a Troubled World" at the dedication of Mezes Hall, new psychology laboratory at the University of Texas. Mr. Henneman of the University of Virginia and Mr. Hinton of Washington and Lee presented papers in two of the sessions. Mr. Hinton also serves as the treasurer of the Society.

At the National Conference on Airborne Electronics held in Dayton, Ohio, on May 11-13, Mr. Henneman read a paper, "Communication During Complex Task Performance", reporting investigations which had been directed by Mr. L. S. Reid and himself at the University of Virginia under a research contract with the U. S. Air Force. — RICHARD H. HENNEMAN

STATISTICS SECTION

Dr. David B. Duncan of Virginia Polytechnic Institute, has been invited to address the American Chemical Society, Division of Industrial and Engineering Chemistry, on September 6-11, 1953, at their Symposium on "Statistics in the Design of Experiments". The title of his talk will be, "Multiple Range Tests and the Multiple Comparisons Test".

For a detailed paper, based on part of the research reported here, presented at the Annual Meeting of the Academy, May 1953, Messrs. Berko and Hereford received the *J. Shelton Horsley Award*. This award is made annually in recognition of the "most highly meritorious paper" presented at the Annual Meeting.

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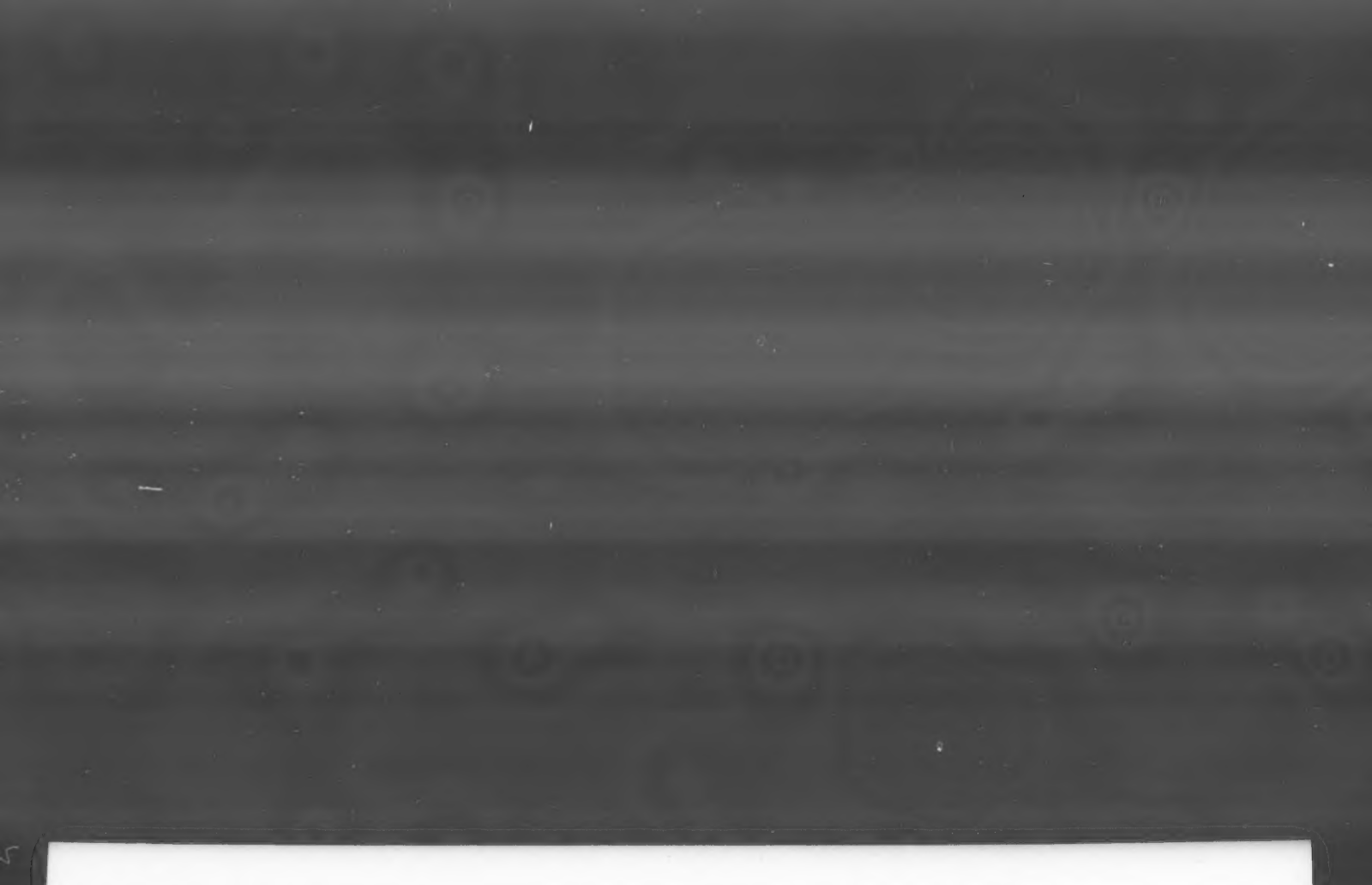
The Division of Statistics and the Division of Markets of the Department of Agriculture, completed a survey of apple and peach trees in commercial orchards. A preliminary report by Henry M. Taylor and Glenn W. Suter was published in March.

Clifford Sims, a former member of the Academy, was transferred to New Jersey in September 1952 and placed in charge of the New Jersey Crop and Livestock Reporting Service of B. A. E. of U. S. D. A.

Thomas L. Stuart, Agricultural Statistician, a native of North Carolina, was transferred from the Alabama office of B. A. E. to Virginia as replacement for Clifford Sims in Crop and Livestock Reporting Service of B. A. E.

Dr. Paul N. Sommerville has been appointed Associate Professor of Statistics at The Virginia Polytechnic Institute. His chief interest will be in Theory Sampling and directing sampling surveys. Dr. Sommerville received his B.Sc. Degree, Magna Cum Laude, in 1945 at the University of Alberta in the honors curriculum in Mathematics. He received his Ph.D. at the University of North Carolina in Statistics in 1953. He has been Principal of a High School in Canada and has had previous research experience with the Defense Research Board in Canada. Dr. Sommerville has published numerous papers including the following:

1. Methods of Estimating the Required Sample Size.
2. A Statistical Study of Flying Accidents in the Royal Canadian Air Force.
3. Optimum Sample Sizes for Choosing the Largest of $(k + 1)$ Means Using Minimax Methods.
4. Optimum Sample Size for Choosing the Largest of $(k + 1)$ Parameters from $(k + 1)$ Otherwise Identically Distributed Populations.

The Department of Statistics has just been awarded a three-year contract with the Army Quartermaster Corps. On this contract there will be three appointments. Two of the appointees are Hale Sweeny and Thomas S. Russell. Mr. Sweeny received his Bachelor's Degree in Mechanical Engineering and his Master's Degree in Industrial Engineering and has completed further work in Statistics. For the past year he has been an Instructor in Industrial Engineering. Mr. Russell received his B.A. Degree from Wake Forest University and his Master's Degree in Chemistry at the Virginia Polytechnic Institute and has completed two years of graduate work in Statistics. He was formerly an Instructor of Mathematics at the Virginia Polytechnic Institute and held a teaching fellowship in the Department of Statistics. — WALTER HENDRICKS